Translation of the Facets During Coupled Motion in the Cervical Spine: A Pilot Study

Facet movements in the mid-cervical spine (C2-C4) were examined on two cervical columns from preserved cadavers.

The dissected columns were clamped to allow manual movement of one vertebra on the fixed vertebra beneath. Pins were inserted to mark the position of the facets, and movement changes recorded photographically; 160 measurements were taken from these photographs.

The study showed that the facets of the free vertebra could be moved to either side in relation to the facets of the fixed vertebra.

Furthermore during movements simulating lateral flexion and rotation, sideways translation of the facets was found to be part of the complex three dimensional motion.

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In the cervical spine, between levels C2-C7, lateral flexion and rotation occur as coupled movements (Fielding 1964, Penning 1968, Lysell 1969).

During these movements the facets move downwards and backwards on one side, and upwards and forwards on the opposite side.

Bakke (1931) observed that during lateral flexion a vertebra slides slightly towards the convex side, and a sideways translation of vertebrae was observed in a clinical study on acute wry necks (Schneider 1981).

If, indeed, a shift or translation of the vertebra to one side is a component of the lateral flexion/rotation coupling, this knowledge could be useful when assessing movement restrictions by palpation.

Furthermore, an accurate understanding of the directions of facet motion is important when relating physiological movements and biomechanics.

No objective studies on these translatory movements could be found in a search of the literature.

A study was commenced in 1982 at the Western Australian Institute of Technology. The study was designed:

1. to establish if a translation of a cervical vertebra does occur, and
2. to determine if this translation is a component of normal physiological movements of the cervical spine between the levels C2-C4.

Materials and Methods

Two preserved male cadavers, one aged 76 years and the other 78 years, were obtained from the Western Australian Institute of Technology's Department of Anatomy. Whilst it was recognized that the two specimens were of a particular age group, and their cervical spines radiologically demonstrated varying degrees of degenerative changes, they were nevertheless similar to cervical spines seen radiologically in the clinical situation.

The cervical columns from the second cervical vertebra to the fifth cervical vertebra were removed from each cadaver. The spine from the 76 year old cadaver was designated specimen one, and that from the 78 year old cadaver specimen two. Both specimens were stored in 10% buffered normal saline until the time of the study.

All muscles were removed. The facet capsules and intervertebral discs, together with the anterior and posterior longitudinal, the interspinous and supraspinous ligaments and the ligamentum flavum, were left intact.

A fine nail was inserted in the coronal plane into each side of the lateral mass of the axis of each specimen. In specimen one, a marking pin was inserted into the tip of the spinous process of the second cervical vertebra, and another into the tip of the spinous process of the third cervical vertebra. Similar pins were inserted into the posterior articular pillars of the second and third cervical vertebrae in close proximity to the facet joint of the C2/3 motion segment. These marking pins lay in the sagittal plane.

In specimen two, pins were inserted in a similar manner into the third and fourth cervical vertebrae (see Figure 1).

Pin and nail location was confirmed by plain roetgenography and tomography. There was no evidence of pin invasion of the facet joints.

Each specimen was then secured in a special clamp so that the caudad vertebral body of the motion segment under examination was firmly held in the vertical position. This permitted movements to be peformed between this clamped vertebra and the free vertebra above.

Pin positions were to be recorded by photographs before a movement was performed, and again once the movement was performed and held at the end of its available range. Measuring the changes in pin positions from the photographs would then indicate facet movements between the free and the clamped vertebra.

A Nikon FM camera with a 105 mm Nikkor macro lens was mounted directly overhead and a second camera, a Nikon FT2 with a 105 mm Nikkor macro lens was positioned laterally. This camera arrangement permitted synchronized overhead and lateral photographs of the specimens and pins.

Eyeball sightings only were made to position the film plane of the overhead camera parallel to the coronal plane of the specimen and the film plane of the lateral camera parallel to the sagittal plane of the specimen. The cameras remained in fixed positions on tripods. Although this arrangement did not eliminate parallax error the emphasis of this study was not on quantitative measurement but to determine if movement occurred at all and, if so, in what direction.

The film used in both cameras was 32 A.S.A. Illford Pan. F., and it was developed in perceptol and processed into 178 mm x 128 mm plates.

All measurements of pin positions were made from these plates with research Mitutoyo calipers, accurate to within 0.05 mm.

Procedure

With the caudad vertebra of the motion segment under study fixed in the clamp, the following movements were performed manually on the free vertebra to both sides

(i) translational glide,

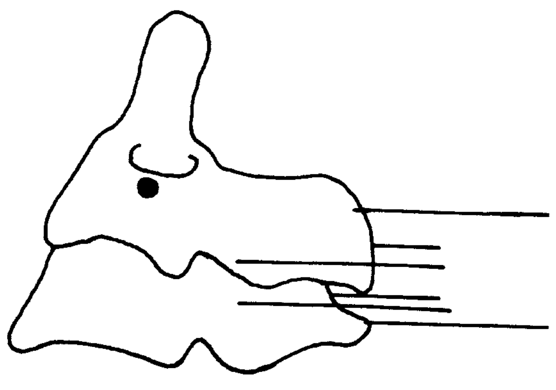
(ii) rotation,

(iii) lateral flexion,

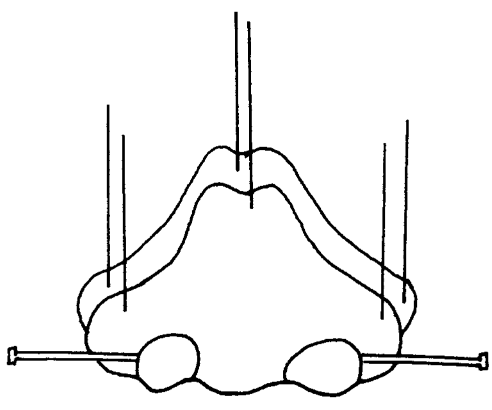
(iv) combined lateral flexion and rotation.

One of the authors performed all the movements on specimen one and the other author performed all of the movements on specimen two. In both specimens, the same sequence of movements was performed. To compensate for creep and hysteresis a movement to the left was always followed by a similar movement to the right. During these procedures, the specimens were regularly perfused with a 10% buffered normal saline solution to maintain tissue moisture.

Synchronized overhead and lateral photographs were taken before each movement was performed. The free vertebra was then moved to the end of its available range for that movement, held in that position and re-photographed (see Figure 2).

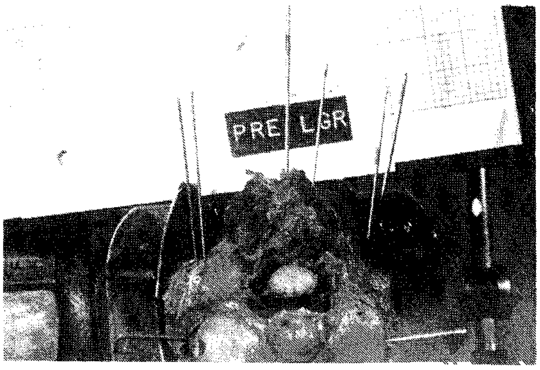


1A



1B

Figure 1: Pin location in specimen one
1A viewed laterally
1B viewed from above



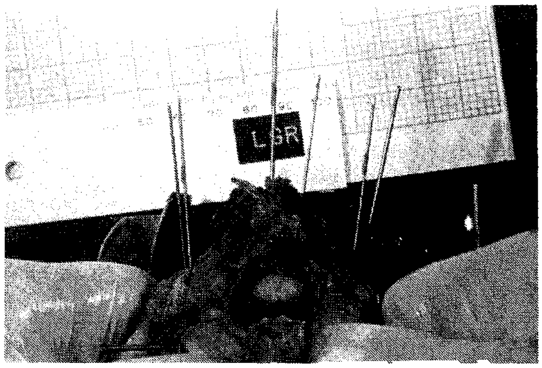


Figure 2: 2A Photograph before translation to the right   2B: Position of pins after translation to the right.

The film was processed and the pin positions were measured with calipers from the overhead photographs. Measurements were made of the distances between the pins in the clamped vertebra and the pins in the free vertebra, and the distances before movement were compared with those after movement. Any changes in these measurements indicated movement of the facets of the free vertebra relative to the fixed vertebra, and the side to side direction of that movement in the coronal plane.

The relative movement between the facets of the two vertebrae was determined from the measurements between the pins in the left articular pillars of each vertebra and also from the measurements between the pins in the right articular pillars.

The direction of movement of the facets of the free vertebra relative to the midline of the fixed vertebra was determined by measuring the changes in the distances between the pins in the facets of the free vertebra and the pin in the spinous process of the fixed vertebra.

Results

In both specimens side to side movements of the facets of the free vertebra were recorded during translational gliding of the vertebrae (see Appendix).

When the free vertebra was moved to the right the facets translated to the right relative to both the midline and to the opposing facets of the fixed vertebra beneath. Translation was also measured when the free vertebra was moved to the left.

Translation of the facets was also recorded during the simulated movements of rotation, lateral flexion and combined lateral flexion and rotation to each side. When these simulated movements were performed to the right side (Figure 3) the right facet of the moving vertebra moved medially with respect to the right facet of the fixed vertebra, and it also moved medially with respect to the midline. Simultaneously, the left facet of the moving vertebra translated laterally with respect to the left facet of the fixed vertebra.

The same pattern of facet movements was demonstrated when the free vertebra was moved to the left. The left facet translated medially and the right facet translated laterally.

These medial and lateral translations were recorded during every simulated physiological movement to both left and right (see Appendix); 160 measurements were taken and the direction of translation of the facets was consistent in every instance.

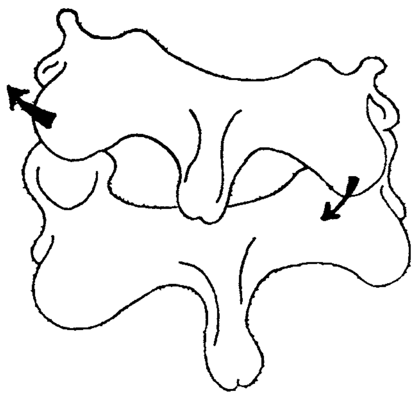


Figure 3: Medial and lateral translations of the facets during movements to the right (Modified from Fielding 1964)

Discussion

These medial and lateral translations of the facets may be explained by examining the location of the axis of the movements.

Consider first the hypothesis that the centre of motion lies in the same coronal plane as the facets (Figure 4).

Then, as the vertebra rotates in a clockwise direction, the facets move about the circumference of a circle. In the instance that the centre of this circle lies between the facets, both facets revolve towards the midline. Such movements however are contrary to the findings of this study.

Alternatively, then consider the directions of movement if the centre of motion lies anterior to the line of the facets (Figure 5).

Once again, as the vertebra rotates, the facets move about the circumference of a circle. But in this instance, with the centre located anteriorly, whilst one of the facets moves towards the midline, the other facet moves laterally away from the midline. Thus, one facet is moving medially, whilst the other is moving laterally, relative to both their previous positions and to the facets beneath.

Therefore, instead of both facets revolving towards the midline, there is a displacement of the posterior columns of the vertebra towards one side, with one facet translating medially and the other laterally.

The location of the centre of motion anterior to the line of the facets is in accord with Lysell's findings. In 1969, Lysell described the centre of motion for lateral flexion and rotation as being situated in the midline at the anterior contour of the vertebral body of the moving vertebra. This being so, it explains the facet movements found clinically and in this study.

The complete intersegmental pattern of motion which occurs in vivo can now be considered.

Fielding (1964) and Penning (1978) showed that in the cervical spine, between levels C2-C7, lateral flexion is always coupled with rotation to the same side and vice-versa. The coupling of these two movements is in part determined by the oblique inclination of the facets.

The upper facets of a caudad vertebra face upwards and backwards to articulate with the inferior facets of the adjacent vertebra which face

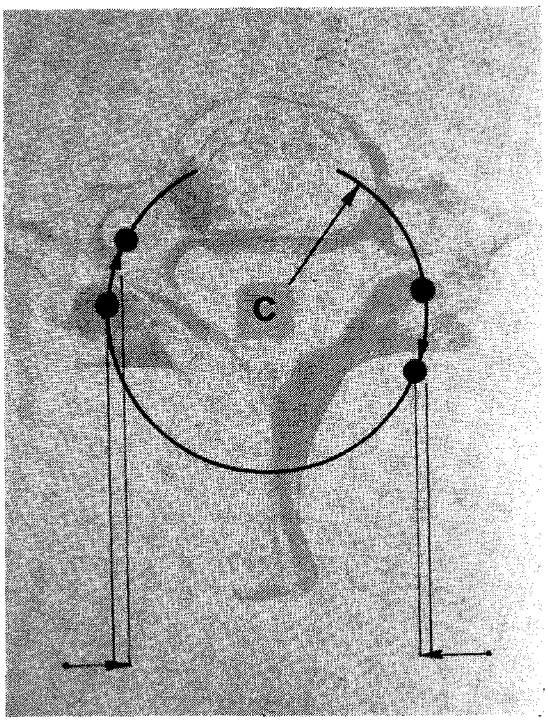


Figure 4: Facet movements if centre of motion lay in the same coronal plane as the facets.

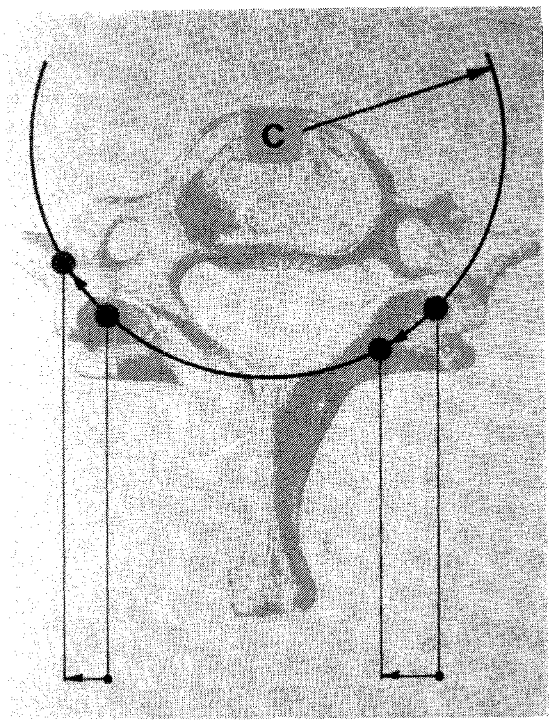


Figure 5: Facet movements with the centre of motion anterior to the line of the facets.

downwards and forwards. When the head is moved to the right, the inferior facets on the right side move downwards and backwards whilst those on the left side move upwards and forwards. This study has shown that coupled with these movements there is a translation of the vertebra to one side to form a complex three dimensional movement.

Consider again the movement of the inferior facets as the head turns towards the right. On the right side the facets move downwards and backwards and also medially, translating towards the midline and falling inside the margin of the facets of the vertebra beneath. Simultaneously on the left side, the facets move upwards, forwards and laterally, translating away from the midline and outside the margin of the opposing facets of the vertebra below.

If facet translation is an integral component of the lateral flexion/rotation coupling, then a movement abnormality of any one component of the three dimensional complex will affect the other two components. Thus, when assessing mid cervical intervertebral movements passively, translation can be included in the tests to gain additional information about the mobility of the motion segment.

Furthermore, translational gliding movements have been found effective as a technique to restore movement restrictions in the neck in selected cases (Schneider 1981).

Appendix

Table 1:
Readings obtained for movement occurring between facets C2/3

	SPECIMEN 1 C2/3								
	Left Facet C2/3			*Right Facet C2/3*			*Spinous Processes C2/3*		
	Before Movement	*After Movement*	*Difference*	*Before Movement*	*After Movement*	*Difference*	*Before Movement*	*After Movement*	*Difference*
Translational glide (L)	3.95	2.65	1.30	3.35	4.90	1.55	10.25	8.45	1.80
Translational glide (R)	4.20	5.55	1.35	3.70	2.60	1.10	10.10	11.75	1.65
Rotation left	4.10	6.00	1.90	3.40	2.15	1.25	10.30	11.50	1.20
Rotation right	4.45	2.35	2.10	3.35	5.40	2.15	10.35	8.50	1.85
Lateral Flexion left	4.35	4.65	0.30	3.45	3.05	0.40	10.35	10.05	0.30
Lateral Flexion right	4.25	4.05	0.20	3.60	4.00	0.40	10.10	10.35	0.25
Lat. Flex. (L) + Rot. (L)	4.55	6.50	1.95	3.40	2.05	1.35	10.30	10.80	0.50
Lat. Flex. (R) + Rot. (R)	4.90	3.00	1.90	3.40	5.15	1.75	10.00	8.75	1.25

Table 2:
Readings obtained for movements occurring between facets C3/4

	SPECIMEN 2 C3/4								
	Left Facet C3/4			*Right Facet C3/4*			*Spinous Processes C3/4*		
	Before Movement	*After Movement*	*Difference*	*Before Movement*	*After Movement*	*Difference*	*Before Movement*	*After Movement*	*Difference*
Translational glide (L)	3.00	3.55	0.55	2.35	0.50	1.85	1.20	2.10	0.90
Translational glide (R)	3.00	2.45	0.55	2.45	2.70	0.25	1.00	0.70	0.30
Rotation left	2.80	0.90	3.70	2.55	4.60	2.05	0.95	2.60	3.55
Rotation right	2.80	5.75	2.95	1.25	1.55	2.80	1.05	4.10	3.05
Lateral Flexion left	3.05	1.00	2.05	1.20	3.00	1.80	1.20	0.10	1.10
Lateral Flexion right	2.90	5.60	2.70	1.30	1.25	2.55	1.10	4.05	2.95
Lat. Flex. (L) + Rot. (L)	2.75	2.05	4.80	1.25	4.20	2.95	1.10	3.35	4.45
Lat. Flex. (R) + Rot. (R)	2.60	7.20	4.60	0.65	2.40	3.05	0.95	5.80	4.85

Table 3:
Readings obtained for movement occurring between the facets of the moving vertebrae, and the mid-line (C2/3)

	SPECIMEN 1 C2/3					
	Left Facet C2			*Right Facet C2*		
	Before Movement	*After Movement*	*Difference*	*Before Movement*	*After Movement*	*Difference*
Translational glide (L)	16.60	18.20	1.60	36.55	34.95	1.60
Translational glide (R)	17.25	15.60	1.65	36.20	37.55	1.35
Rotation left	16.65	15.10	1.55	36.50	37.55	1.05
Rotation right	16.80	18.75	1.95	36.45	34.60	1.85
Lateral Flexion left	16.55	16.30	0.25	36.35	36.55	0.20
Lateral Flexion right	15.85	17.15	1.30	36.60	36.25	0.35
Lat. Flex. (L) + Rot. (L)	16.60	15.20	1.40	36.30	36.80	0.50
Lat. Flex. (R) + Rot. (R)	16.60	18.25	1.65	36.20	34.30	1.90

Table 4:
Readings obtained for movement occurring between the facets of the moving vertebrae, and the mid-line (C3/4)

	SPECIMEN 2 C3/4					
	Left Facet C3			*Right Facet C3*		
	Before Movement	*After Movement*	*Difference*	*Before Movement*	*After Movement*	*Difference*
Translational glide (L)	29.05	29.50	0.45	24.25	22.15	2.10
Translational glide (R)	29.05	28.45	0.60	24.50	24.60	0.10
Rotation left	29.20	25.70	3.50	24.50	26.60	2.10
Rotation right	29.10	31.85	2.75	23.30	20.35	2.95
Lateral Flexion left	29.05	27.45	1.60	23.05	24.30	1.25
Lateral Flexion right	29.10	31.50	2.40	23.20	20.55	2.65
Lat. Flex. (L) + Rot. (L)	28.95	24.80	4.15	23.10	25.80	2.70
Lat. Flex. (R) + Rot. (R)	28.60	33.25	4.65	22.45	18.85	3.60

Conclusion

The findings of this introductory study have shown that

1. between the segments C2-C4 it is possible for the facets to translate to either side, and that
2. the physiological movements of lateral flexion and rotation are a three dimensional complex, with translation an integral part of the motion.

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